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# Rockfall monitoring at a high-temporal rate using cost-effective photogrammetric systems

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Monitoring rock slope failures in natural environments using LiDAR has considerably increased our understanding of rockfall phenomena during the last decade, but the economic and logistic costs associated with the instrument and data acquisition has considerably limited our ability to increase the frequency of monitoring campaigns, especially in remote areas. More recently, emerging UAV platforms with on-board LiDAR systems and continuous monitoring with terrestrial LiDAR are considerably increasing the high frequency of the data acquisition, but again at a significant cost.

Alternatively, and attempting to overcome these limitations, a series of cost-efficient and permanently installed photogrammetric sensors and advanced methodologies for 4D reconstruction and rockfall extraction are being explored in this work. We will be showing the design of a photogrammetric system consisting on five time-lapse cameras that were specifically designed for this research. Each system consists on a small single-board computer (Raspberry Pi), a low-cost 8Mpx camera (Raspberry Pi Camera Module V2), batteries, solar panels and data transfer by 4G. This is an ongoing experiment, and we will be sharing some of the challenges encountered during the system installation, maintenance and data processing.

The global aim of this research is to characterize the whole spectrum of rockslope failures at a high temporal rate in our pilot study area at Puigcercós cliff (Conca de Tremp-Montsec UNESCO Global Geopark). This system will be helping us studying both the progressive development of surface deformation at local parts of the slope and subsequent rupture. When comparing this photogrammetric system with occasional data acquisition with terrestrial LiDAR, we observed how an increase of the temporal resolution -daily data acquisition- has helped us better characterizing and constraining a recent failure that occurred on 27th December 2018, with a volume of 500m3. An attempt to link precursory deformation and subsequent rock slope failure with environmental forcing will also be discussed.